TM 11-320

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

FREQUENCY-POWER METER-51/UP

ME 51/UP

3100 - 3500 MC

DEPARTMENT OF THE ARMY • NOVEMBER 1956

AGO 2758A—Nov

WARNING

HIGH VOLTAGE

is used in the operation of equipment under test

DEATH ON CONTACT

may result if operating personnel fail to observe safety precautions.

Be careful not to contact high-voltage connections or any power connections when using this equipment. Discharge all high-voltage capacitors by short-circuiting them after the power has been turned off before making any test combinations or working inside the equipment under test.

TECHNICAL MANUAL No. 11-320

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *14 November 1956*

FREQUENCY-POWER METER ME-51/UP

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual contains instructions for the installation, operation, and maintenance of Frequency-Power Meter ME–51/UP. Throughout this manual Frequency-Power Meter ME–51/UP will be called the frequency-power meter.

b. Forward comments on this publication directly to Commanding Officer, The Signal Corps Publications Agency, Fort Monmouth, N. J.

2. Forms and Records

a. Unsatisfactory Equipment Reports. Fill out and forward DA Form 68, Unsatisfactory Equipment Report, to Commanding Officer, Signal Equipment Support Agency, Fort Monmouth, N. J., as prescribed in AR 700–38.

b. Damaged or Improper Shipment. Fill out and forward DD Form 6, (Report of Damaged or Improper Shipment), as prescribed in AR 700–58 (Army); Navy Shipping Guide, Article 1850–4 (Navy); and AFR 71–4 (Air Force).

c. Preventive Maintenance Forms.

(1) Prepare DA Form 11–238, (Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)), in accordance with instructions on the back of the form (fig. 10).

(2) Prepare DA Form 11–239, (Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)), in accordance with instructions on the back of the form (fig. 11).

Section II. DESCRIPTION AND DATA

3. Purpose and Use

The frequency-power meter is a portable meter designed to measure the power and frequency of continuous-wave (cw) or pulsed signals in the 3,100- to 3,500-megacycle (mc) portion of the S band. The frequency-power meter is used to test the performance of radar transmitters.

4. Technical Characteristics

Frequency range .... 3,100 to 3,500 mc.

Input power range:
- Without cords .... 0.5 to 12.5 mw.
- With Cord CG–258/U .... 5 to 125 mw.
- With Cord CG–258/U and Cord CG–358/U. .... 10 to 250 mw.

Meter Scales:
- Milliamperes .... 0 to 1.5
- Milliwatts .... 0 to 22.5.

Cable insertion loss:
- Cord CG–258/U .... 10 db.
- Cord CG–257/U .... 1.25 db.
- Cord CG–256/U .... 0.5 db.
- Cord CG–358/U .... 3 db.

Impedance of RF connectors .... 50 ohms.

Accuracy of measurement:
- Frequency .... ±2 mc.
- Power .... ±1 db.

Power supply:
- 3 Batteries BA–30 .... 1.5 volts.

Weight .... 12 lb.

5. Common Names of Components

Nomenclature	Common name
Cord CG–257/U	Low-loss cable
Cord CG–258/U	10-db cable
Cord CG–358/U	3-db cable
Cord CG–256/U	Patch cable

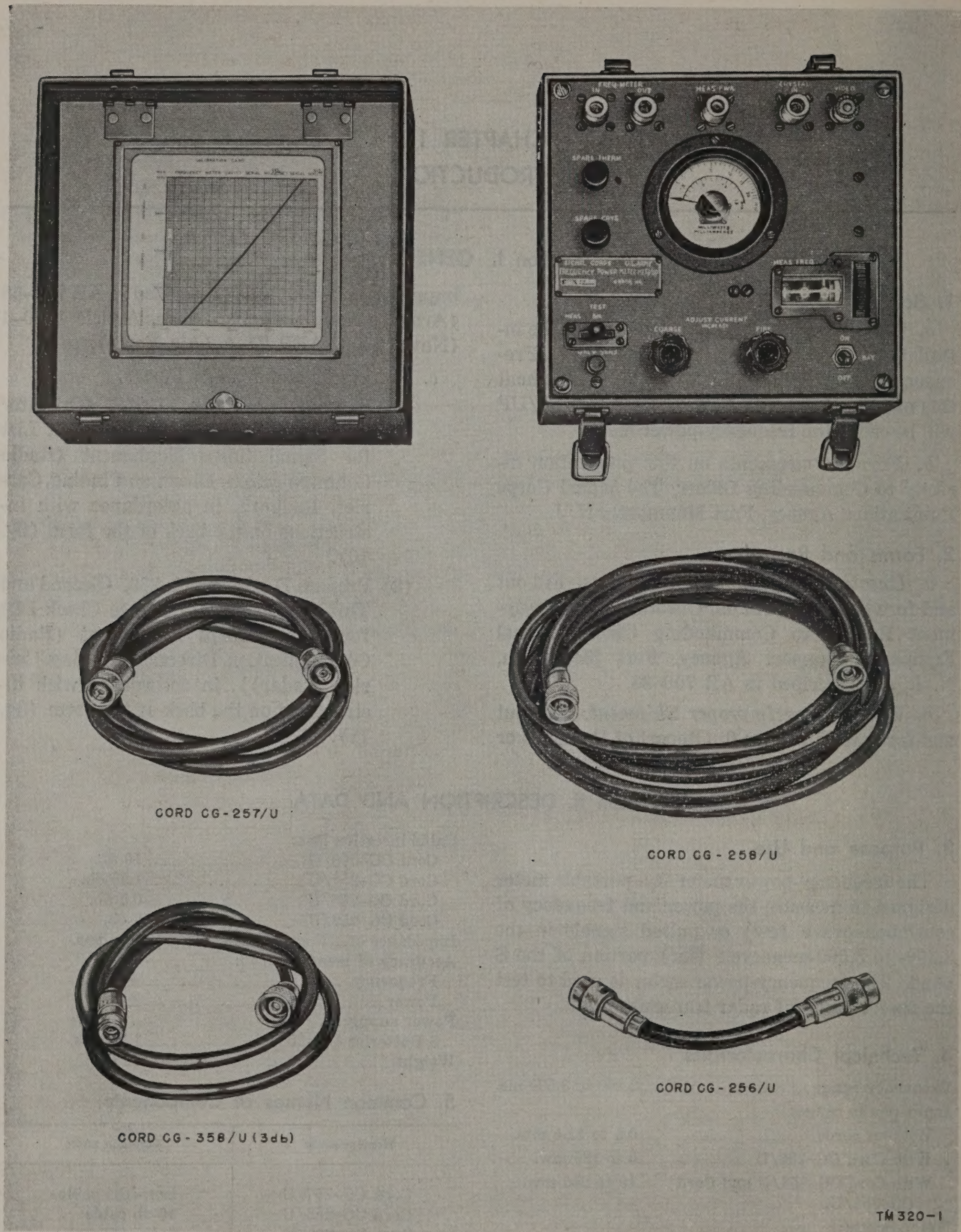


Figure 1. Frequency-Power Meter ME-51/UP.

6. Table of Components

Component	Required No.	Length (in.)	Width (in.)	Depth (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Frequency-Power Meter	1		9⅛	9½	11⅜	.57	12
Manual TM 11–320	2						
Cord CG–258/U	1	132					
Cord CG–257/U	1	60					
Cord CG–256/U	1	6					
Cord CG–358/U	1	41					
Wrench, Allen No. 8	1	1⅞					
Running spares (par. 8)							
Total							12

Note. This list is for general information only. See SIG 7 and 8 ME–5/UP for information pertaining to requisition of spare parts. Refer to paragraph 8 for a list of additional parts required but not supplied.

7. Description

a. The frequency-power meter consists of a panel-chassis assembly in an aluminum case. The case is equipped with a cover and a carrying handle. The cover is held in place by four latches and protects the controls. It has a compartment to hold all the cables and the Allen wrench. All controls and connectors are located on the top panel.

b. The four cables used with the frequency-power meter are shown in figure 1. They are stored in the cover as shown in figure 2. The following is a description of the accessories supplied with the frequency-power meter.

(1) *Cord CG–258/U.* This cord consists of 11 feet of Radio Frequency Cable RG–21/U with Radio Frequency Plug UG–18B/U on each end.

(2) *Cord CG–257/U.* This cord consists of a 5-foot length of Radio Frequency Cable RG–9B/U with Radio Frequency Plug UG–21/U on each end.

(3) *Cord CG–256/U.* This cord consists of 6 inches of Radio Frequency Cable RG–5B/U with Radio Frequency Plug UG–18B/U on each end.

(4) *Cord CG–358/U.* This cord consists of approximately 40 inches of Radio Frequency Cable RG–21A/U with a Radio Frequency Jack UG–20B/U on one end and a Radio Frequency Plug UG–18B/U on the other end.

(5) *Allen wrench.* An Allen wrench is located in a holder on the meter cover. The wrench is used to tighten or loosen the set screws in the control knobs.

8. Running Spares

The crystal and the thermistor are the only items for which a spare is provided. The spare crystal and spare thermistor are stored in holders on the front panel. They are marked SPARE THERM and SPARE CRYS.

9. Additional Equipment Required

Three Batteries BA–30 are not supplied with the frequency-power meter but are required for its operation.

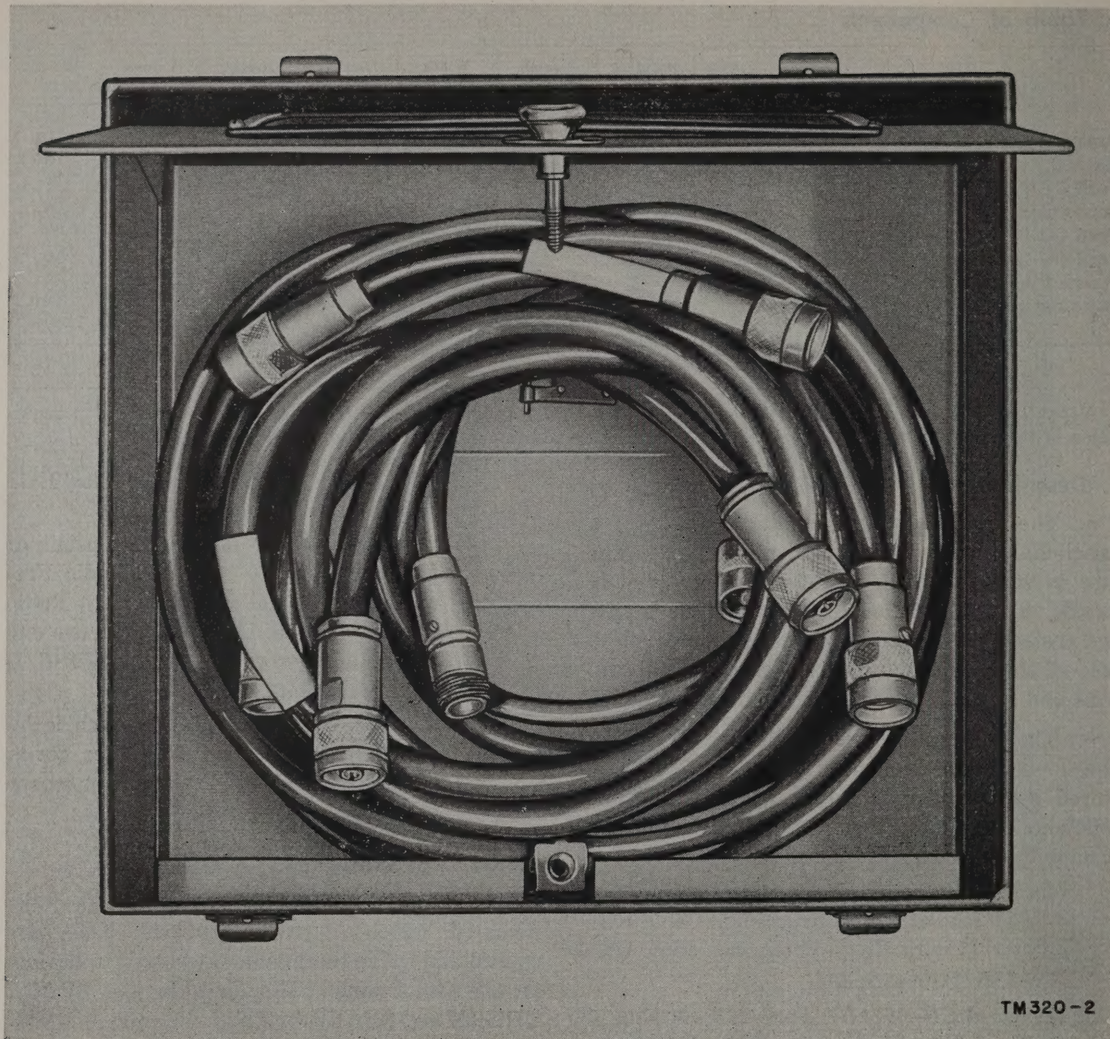


Figure 2. Cable compartment open.

CHAPTER 2
INSTALLATION AND OPERATION

Section I. INSTALLATION

10. Packaging Data

When packed for shipment, the frequency-power meter is placed in moisture-vaporproof containers and packed in one wooden case. The case is 12 inches long, 12 inches wide, 14 inches deep, has a volume of 1.1 cubic feet, and weighs 16 pounds. A view of a typical shipping case is shown in figure 3.

11. Checking New Equipment

a. Remove the frequency-power meter from its packing case (fig. 3) and check the contents against the packing slip. Check the equipment to see if it has been damaged.

b. If the frequency-power meter is a used or reconditioned equipment, check for tags or other indications of a change in the wiring. If changes in wiring have been made, note them in this manual preferably on the schematic diagram. Check the completeness of used or reconditioned equipment against the table of components (par. 6).

12. Installation of Equipment

a. Install Batteries.

(1) Remove the frequency-power meter (fig. 4) from its cabinet.

(2) Remove the four screws that hold the battery plate (fig. 15).

(3) Insert three Batteries BA–30 with the positive terminals facing inward.

(4) Replace the battery plate and put the frequency-power meter back in its cabinet.

b. Location for Proper Operation. Place the frequency-power meter on a firm support close to the directional coupler or test jack of the radar set under test. The front panel of the frequency-power meter must be in a horizontal position and placed so that the meter may be easily read. Place the jacks and connectors so they are easily connected to the test points on the radar set. Refer to the radar set manual to determine the proper test points for measuring power and frequency.

Caution: Do not allow test cables to drape across radio-frequency (RF) circuits. Personnel may be severely burned or the equipment may become damaged.

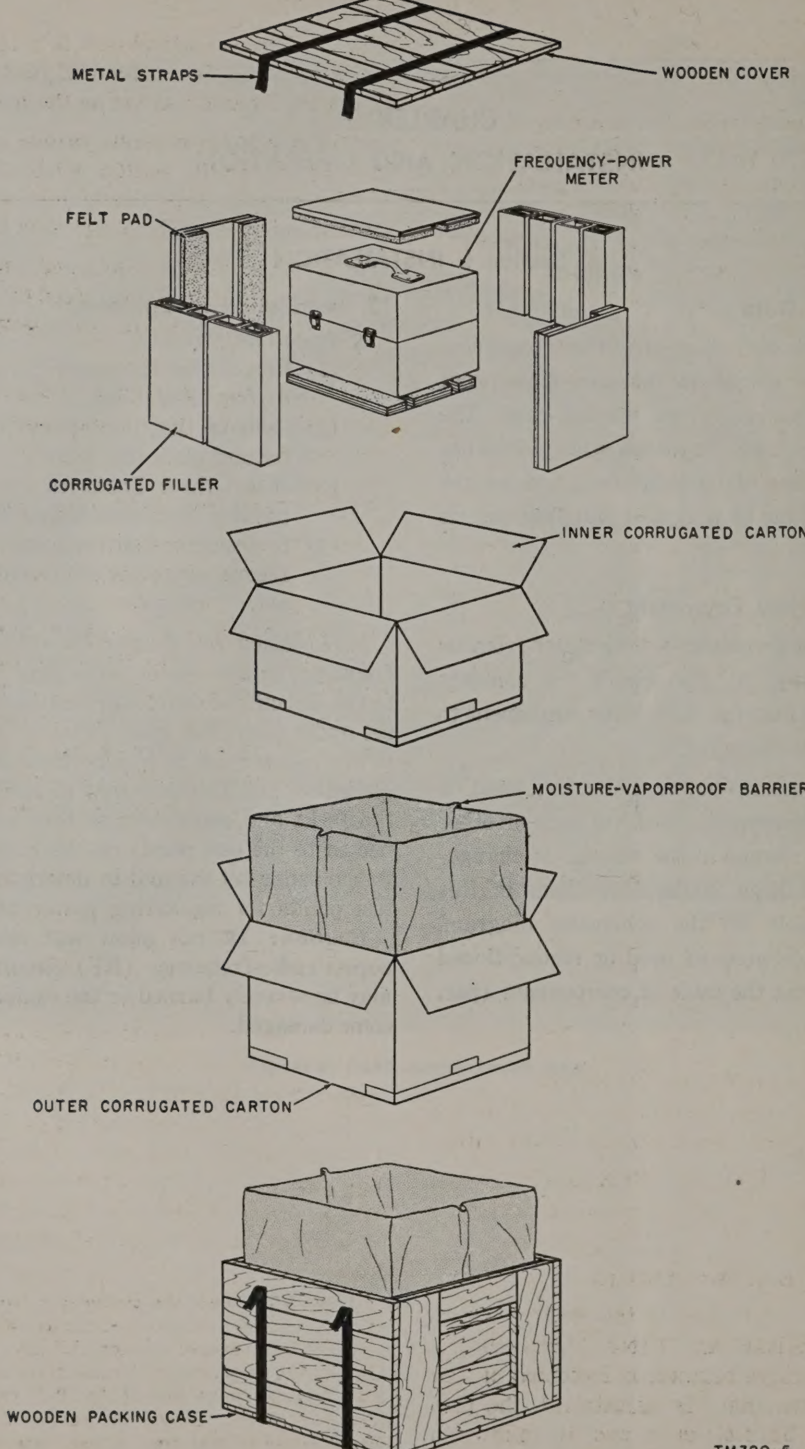


Figure 3. Packing and packaging Frequency-Power Meter ME-51/UP.

13. Controls and Their Uses (fig. 4)

It is important to know the function of every control, connector, and cable used with the frequency-power meter, to be able to intelligently operate the equipment. The following chart lists the controls and connectors of the frequency-power meter and indicates what they do.

Controls and connectors	Function
BAT switch	Turns frequency-power meter on or off.
MEAS FREQ dial	Indicates frequency of RF power being measured.
ADJUST CURRENT knobs.	
COARSE	Balances bridge.
FINE	Vernier adjust on COARSE control.
TEST key	In BAL position. Balances bridge circuit with dc. In MEAS position. The dc current required to balance the bridge is measured.
GALV SENS button	Increases sensitivity of circuit.
FREQ METER jacks	
IN	Input to frequency meter.
OUT	Output of frequency meter.
MEAS PWR jack	Input to bridge circuit.
CRYSTAL jacks	
IN	Input to crystal chamber.
VIDEO	Output of crystal chamber.

Warning: High voltage is used in the EQUIPMENT UNDER TEST. DEATH ON CONTACT may result if operating personnel fail to observe safety precautions.

14. Preliminary Measuring Procedure

The following steps must be performed before a power or frequency measurement can be made.

a. Turn the ADJUST CURRENT knobs, COARSE and FINE, to their maximum counterclockwise position.

b. Throw the BAT switch to ON.

c. With the TEST key in the BAL position, adjust the COARSE and FINE knobs until a zero reading, bridge balance, is indicated on the meter. When making this adjustment, the first indication will be between 3 and 10 milliwatts (mw), after which the reading will decrease to zero. Be sure the adjustment is made to zero only and not lower. The meter will read in a counterclockwise direction as far as the meter stop.

d. For a more accurate bridge balance, press the GALV SENS button while adjusting the FINE control. This should not be done if the meter reading exceeds .5 mw or is less than zero.

e. When a balance is obtained, place the TEST key in the MEAS position. Read the meter on the mw scale. Record this as reading No. 1 in step 1 of figure 8.

f. Turn the ADJUST CURRENT knobs COARSE and FINE to a maximum counterclockwise position.

15. Procedure for Measuring Power

The chart in figure 8 shows a sample calculation for determining the transmitter peak power: Assume that the transmitter power of a radar system, operating with a repetition rate of 400 pulses per second (pps) and a pulse duration of 1 microsecond, is being measured. The measurements made by the frequency-power meter, reading No. 1 and reading No. 2, are listed on the chart with the procedure required to determine peak power. The procedure in *a* through *h* below are used with figure 8.

a. Turn off the RF power source to be measured.

b. Connect the output terminal of the RF power source through the 10-decibels (db) cord to the MEAS PWR jack. If the power output of a radar transmitter is being measured, connect the direct power jack of the directional coupler in the radar transmission line to the MEAS PWR jack of the frequency-power meter; use the 10-db cord. The 10-db cord has an attenuation of 10 db at 3,500 mc only. If the frequency of the power being measured is lower than 3,500 mc, the attenuation will be less. Use the graph in figure 6 to determine the attenuation at frequencies below 3,500 mc.

Note. To protect the thermistor from damage, two attenuator cords are provided for use when the average power to be measured exceeds 12.5 mw. The 10-db cord extends the power range frequency-power meter to 125 mw. A series connection of the 10-db cord and the 3-db cord will further extend the range of the frequency-power meter to 250 mw. Always use both attenuator cords when the power to be measured is unknown.

Figure 4. Front panel view.

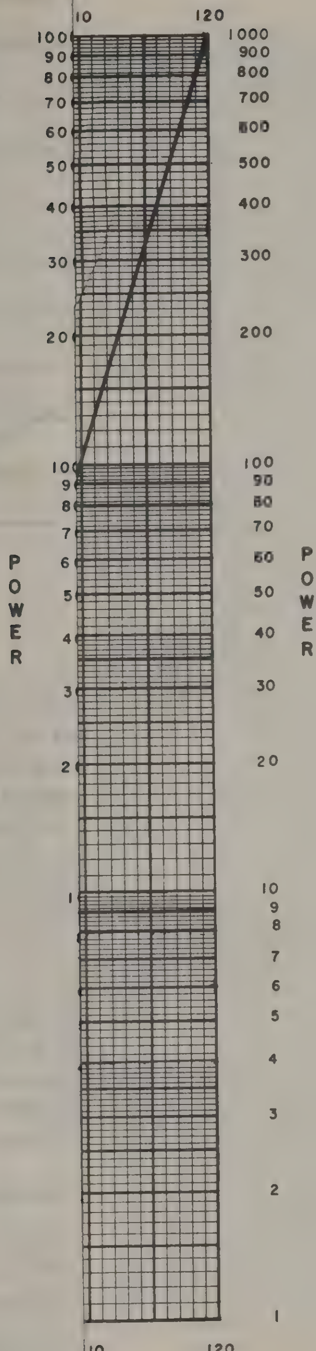
c. Turn on the RF power source.

d. Repeat the preliminary operation described in paragraph 14*a* through *d*.

Note. If the meter reading cannot be decreased to zero (bridge balance), the power is greater than this meter can measure.

e. When a bridge balance is obtained, place the TEST key in the MEAS position and again read the meter on the mw scale. Record this as reading No. 2 (step 2, fig. 8).

f. The RF power in mw at the MEAS PWR jack is reading No. 1 minus reading No. 2 (step 3, fig. 8). To obtain the RF power in mw at the input to the connecting cable, multiply the reading obtained by 10.



10
120
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
POWER
POWER

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Figure 4. Front panel view.

c. Turn on the RF power source.

d. Repeat the preliminary operation described in paragraph 14*a* through *d*.

Note. If the meter reading cannot be decreased to zero (bridge balance), the power is greater than this meter can measure.

e. When a bridge balance is obtained, place the TEST key in the MEAS position and again read the meter on the mw scale. Record this as reading No. 2 (step 2, fig. 8).

f. The RF power in mw at the MEAS PWR jack is reading No. 1 minus reading No. 2 (step 3, fig. 8). To obtain the RF power in mw at the input to the connecting cable, multiply the reading obtained by 10.

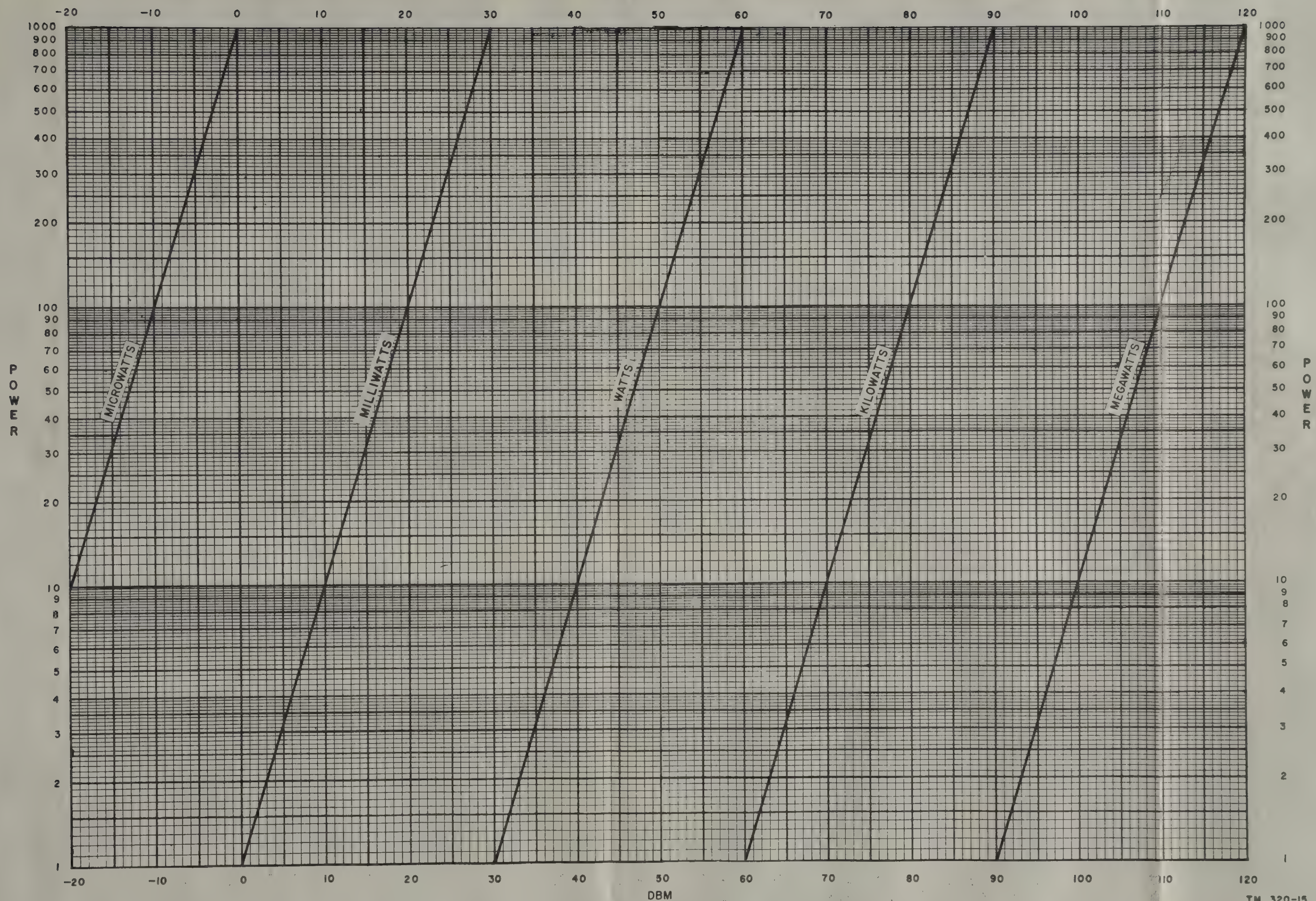

Figure 5. Relation of power and dbm.

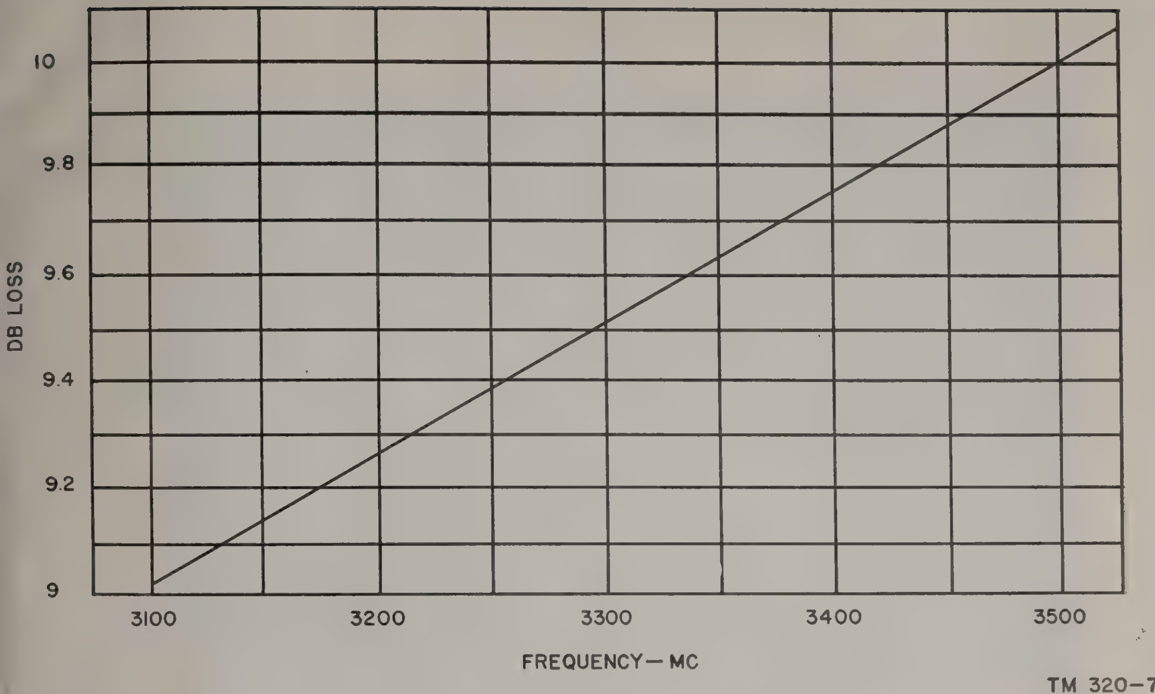

Figure 6. Loss characteristics of 10-db cable.

g. To convert a reading in mw to dbm, use the graph in figure 5. For an example of how the graph in figure 5 is used, assume that 100 milliwatts is to be converted to dbm. On figure 5, find the line that corresponds to 100 on the power scale. Follow this line to the point where it intersects the milliwatt curve. From this point, follow the dbm line to dbm scale and read 20 dbm (step 4, fig. 8).

h. The rated power of a radar transmitter is usually expressed in peak pulse power. Frequency-Power Meter ME–51/UP can only measure average power. The average power is shown in step 8 of figure 8. To find the peak power, perform steps 13, 14, 15, and 16 on figure 8.

16. Frequency Measurement

To measure frequency with the thermistor as the indicator, proceed as follows:

a. Turn off the RF source to be measured.

b. Connect the output of the direct power jack of the radar's directional coupler to the FREQ METER IN jack of the frequency-power meter. Use the proper cords (par. 15*b*).

c. Connect the FREQ METER OUT jack to the MEAS PWR jack by using the 6-inch patch cord.

d. Throw the BAT switch to ON.

e. Detune the frequency-power meter by turning the MEAS FREQ knob at least 200 divisions from the setting corresponding to the expected radar frequency.

f. Turn on the RF source to be measured.

g. Adjust the ADJUST CURRENT knobs COARSE and FINE with the TEST key in the BAL position until a bridge balance is obtained.

h. Turn the MEAS FREQ knob of the frequency-power meter slowly until a maximum deflection is obtained on the meter. If the RF power is less than 4 mw, depress the GALV SENS button before turning the MEAS FREQ knob. When the meter needle has reached its peak, adjust the COARSE and FINE knobs until the needle is again at zero or minimum. Depress the GALV SENS button and again adjust MEAS FREQ knob to give a maximum meter reading. The thermistor is a comparatively slow-acting device; move the MEAS FREQ dial very slowly when adjusting for maximum.

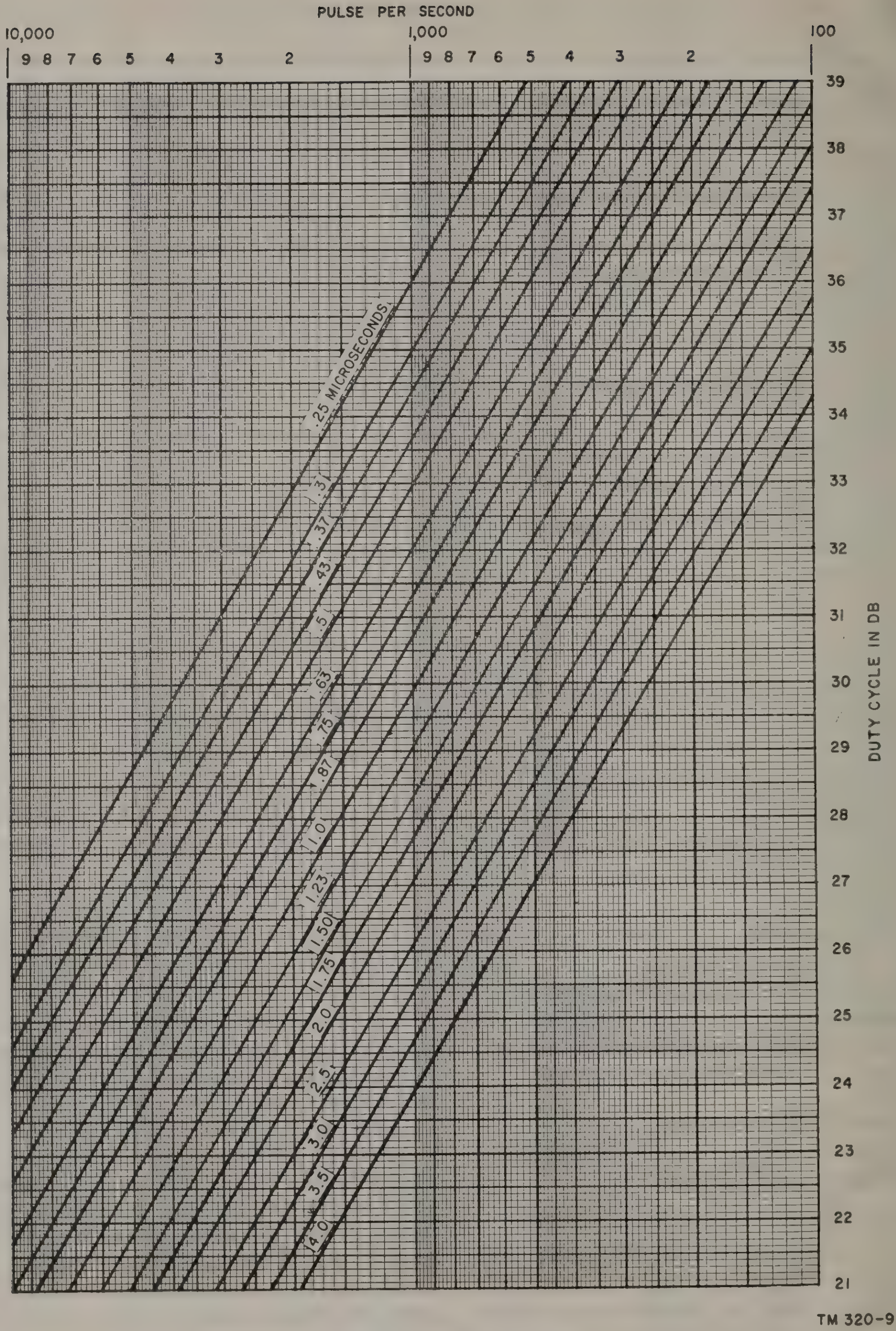

Figure 7. Duty cycle chart.

RECORD OF TRANSMITTER POWER MEASUREMENTS

Serial number of radar being measured 274

MEASUREMENT AND CALCULATION OF AVERAGE POWER

		Date						
1. Meter reading (rf disconnected)........	mw	13.0						
2. Meter reading (rf connected)..........	mw	5.0						
3. Average rf power (Item 1 - Item 2)......	mw	8.0						
4. Convert Item 3 to dbm (see fig. 5).......	dbm	9.0						
5. 10-db Cable loss (corrected for frequency, see fig 6)...........................	db	9.5						
6. 3-db Cable loss (if used; no correction)...	db	3.0						
7. Directional coupler (loss stamped on coupler)........................... or Antenna space loss	db	34.0						
8. Radar main transmission line loss (0.02 db per ft)...........................	db							
9. Average power output of transmitter (sum of Items 4 to 8 inclusive).............	dbm	55.5						
10. Rated average output of transmitter......	dbm	60.0						
11. Measured average power (Item 9)........	dbm	55.5						
12. Difference between measured and rated average power (Items 10 and 11. Record as - if measured power is the smaller, + if measured power is the greater.)....	db	-4.5						

CALCULATION OF PEAK POWER

13. Average power (Item 9)................	dbm	55.5						
14. Duty cycle (From radar instruction book or from fig. 7)......................	db	34.0						
15. Peak power (Item 13 + Item 14)..........	dbm	89.5						
16. Convert Item 15 to kw (See fig. 5)......	kw	887.5						

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Figure 8. Example of computation of radar peak and average power.

i. Read the MEAS FREQ dial counter setting and determine the frequency as follows:

(1) The setting of the MEAS FREQ counter is read to four places, for example 2160.

(2) Find this reading, 2160, at the bottom of the calibration card (fig. 9).

Caution: Before using the calibration card in the lid, be sure the frequency-power meter cavity number on the chart agrees with the cavity number on the panel name plate.

(3) Follow the vertical line, 2160, up until it intersects the curve.

(4) Follow the point of intersection to the left.

(5) Read the frequency in megacycles at the left, in this example the frequency is 3,300 mc.

17. Adjusting a Signal Generator to Desired Output

a. Balance the frequency-power meter as described in paragraph 14*a* through *d*. The desired power to which the signal generator is to be adjusted must be smaller than reading No. 1 obtained in paragraph 14*e*.

b. Subtract the desired power from reading No. 1.

c. With the TEST key in the MEAS position, adjust the COARSE and FINE controls until the

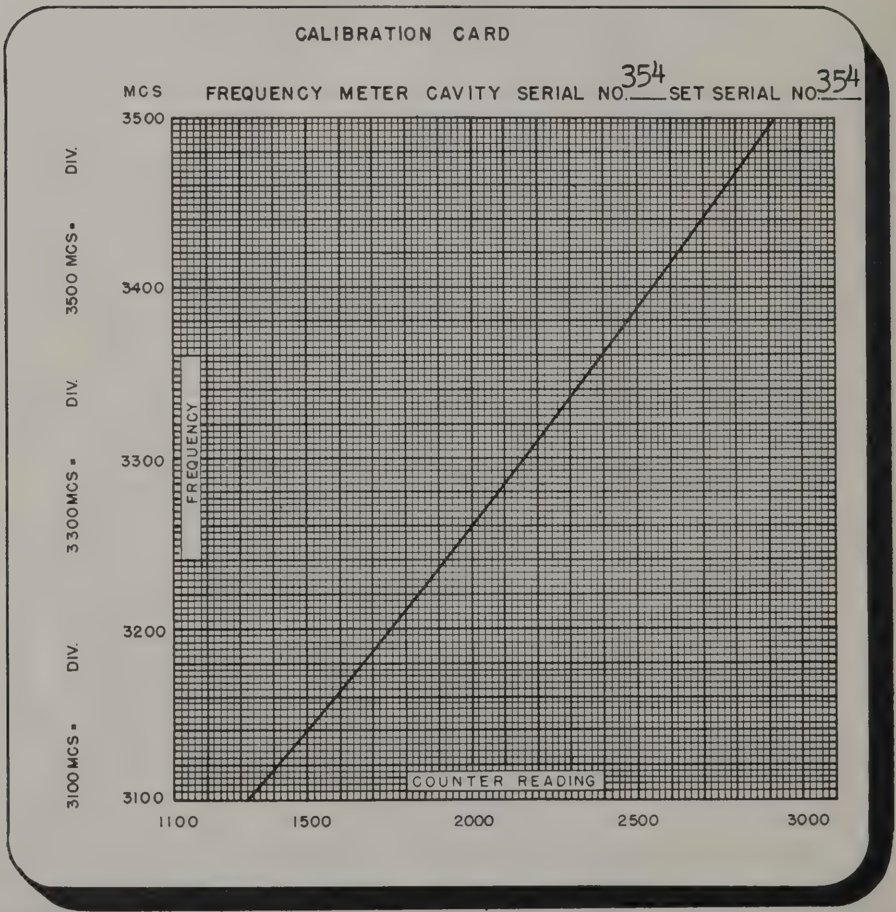


Figure 9. Calibration card.

meter reads the mw determined in *b* above. Release the TEST key.

d. Connect the RF power from the signal generator to the MEAS PWR jack.

e. Adjust the output of the signal generator until the bridge is balanced. Depress the GALV SENS button and balance again. The output of the signal generator is now at the desired value.

18. Measurement of Reflected Power and Standing Wave Ratio

a. Measurements of direct and reflected powers are required to determine the standing wave ratio (swr) in the RF transmission line of the radar equipment. The procedure for measuring reflected power is the same as that for measuring direct power except that connection is made to the reflected power output jack on the directional coupler.

b. Measure the direct and reflected powers and change mw power to dbm (fig. 5). The db difference between the reflected power and the direct power can be expressed in terms of swr. Voltage swr corresponding to db differences between direct and reflected power are given in *c* below. If the reflected power is less than .5 mw, use the 5-foot, low-loss cable in the connection to the measuring set. In this case, it will be necessary to take into account the different loss of the cable by calculating the power at the directional coupler end of the cable. In most radar sets, the swr should be less than 2 to 1.

c. The following is a chart showing the relation between reflected and direct power voltage standing wave ratios, and reflection loss.

D–R[a]	Corresponding swr[b]	Resulting db reflection loss in radiation power[c]
Infinity	1.0	0
26.4	1.1	.010
20.8	1.2	.036
17.7	1.3	.074
15.6	1.4	.12
14.0	1.5	.18
12.8	1.6	.23
11.7	1.7	.30
10.9	1.8	.37
10.2	1.9	.44
9.6	2.0	.50
9.0	2.1	.59
8.5	2.2	.66
8.1	2.3	.73
7.7	2.4	.81
7.3	2.5	.90
7.0	2.6	.96
6.7	2.7	1.05
6.5	2.8	1.1
6.2	2.9	1.2
6.0	3.0	1.3
4.4	4.0	2.0
3.5	5.0	2.6
2.9	6.0	3.1
2.5	7.0	3.6
2.2	8.0	4.0
1.9	9.0	4.5
1.75	10.0	4.8
0.9	20.0	7.3

[a] = Direct power in dbm, R = Reflected power in dbm.

[b] = The ratio of the maximum to the minimum voltage of the standing wave existing on the transmission line. Limiting values of swr are given in manuals for some radars.

[c] The db reflection loss column expresses the db loss in power of the direct wave that is finally radiated from the antenna.

19. Uses of Crystal

a. As Detector for Viewing Pulses On Oscilloscope.

(1) Connect CRYSTAL IN jack to the pulsed RF source to be detected. The peak power at the input jack of the crystal should not be allowed to exceed 1 watt (+30 dbm). The reflected power output of the directional coupler connected through the 10-db cable will usually meet this requirement.

Caution: The crystal unit in the detector section has a maximum peak power input rating of 1 watt (+30 dbm). To prevent overload of the crystal when peak power in excess of 1 watt is to be measured, use the attenuator cables.

(2) Connect an oscilloscope to the VIDEO jack. This oscilloscope should be self-triggering or synchronized with the transmitter sending out the pulsed power.

(3) The pulses can now be viewed on the oscilloscope.

b. Measurement of Frequency of Pulsed Signal Using Crystal.

(1) The crystal with an oscilloscope as an indicator can be used when measuring the frequency of pulsed RF signals where the peak power does not exceed 1 watt (+30 dbm) at the CRYSTAL IN jack.

(2) Connect the pulsed RF source to be measured to the FREQ METER IN jack.

(3) Connect the FREQ METER OUT jack to the CRYSTAL IN jack with the 5-foot low-loss cable.

(4) Connect the VIDEO jack to an oscilloscope.

(5) With the frequency meter detuned, adjust the screen image on the oscilloscope to a convenient size for viewing.

(6) Tune the frequency meter until the center of the pulse image on the oscilloscope screen is reduced to a minimum. At this point, the frequency meter is tuned to resonance.

(7) Read the frequency indicator setting and determine the frequency from the calibration card (fig. 9).

CHAPTER 3
ORGANIZATIONAL MAINTENANCE

Section I. PREVENTIVE MAINTENANCE

20. Tools and Materials

The following is a list of tools and materials used but not supplied with the frequency-power meter:

Tool Equipment TE–113
Cheesecloth, bleached, lint-free
Sandpaper, flint No. 000
Cleaning Compound (Federal stock No. 7930–395–9542)

21. Definition of Preventive Maintenance

Preventive maintenance is the work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from trouble shooting and repair since its objective is to prevent certain troubles from occurring.

22. General Preventive Maintenance Techniques

a. Use No. 000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or brush for cleaning. If a dry cloth or brush will not remove the dirt, use a cloth or brush moistened in cleaning compound and then wipe the parts dry with a clean cloth.

Caution: Prolonged breathing of cleaning compound is dangerous. Make sure adequate ventilation is provided. Cleaning compound is flammable; do not use near a flame.

23. Use of Preventive Maintenance Forms (figs. 10 and 11)

a. First Echelons.

(1) DA Form 11–238 is a preventive maintenance check list to be used by the operator.

(2) Items not applicable to Frequency-Power Meter ME–51/UP are lined out on figure 10.

b. Second Echelon.

(1) DA Form 11–239 is a preventive maintenance checklist to be used by second echelon repairmen.

(2) Items not applicable to Frequency-Power Meter ME–51/UP are lined out on figure 11.

24. Performing Preventive Maintenance

To insure operation of equipment, the inspection and maintenance procedure listed in figures 10 and 11 should be followed by operating and maintenance personnel.

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.

NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (~~receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).~~							
2	~~LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.~~							
3	~~CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.~~							
4	~~INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.~~							
5	~~INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.~~							
6	CHECK FOR NORMAL OPERATION.							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	CLEAN AND TIGHTEN EXTERIOR ~~OF COMPONENTS~~ AND CASES, ~~RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.~~		13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~	
8	~~INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE.~~		14	~~CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.~~	
9	~~INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN.~~		15	INSPECT METERS FOR DAMAGED GLASS AND ~~CASES.~~	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		16	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING.~~	
11	~~INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.~~		17	~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~	
12	~~INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWER-STATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.~~		18	~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 11-238 1 MAY 51 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM320-16

Figure 10. DA Form 11-238.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT ~~(receiver, transmitter,~~ *carrying cases, wire and cable,* ~~*microphones, tubes,*~~ *spare parts, technical manuals and accessories).*		19	~~ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS; INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER-TYPE TUBES.~~	
2	~~LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.~~		20	~~INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.~~	
3	CLEAN DIRT AND MOISTURE FROM ~~ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS,~~ JACKS, PLUGS, ~~TELEPHONES, CARRYING BAGS, COMPONENT~~ PANELS.		21	~~INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION.~~	
4	~~INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.~~		22	~~INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.~~	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, ~~WORN OR CHIPPED GEARS, MISALIGNMENT~~, POSITIVE ACTION.		23	~~INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.~~	
6	~~CHECK FOR NORMAL OPERATION.~~		24	INSPECT RESISTORS, ~~BUSHINGS, AND INSULATORS~~, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE.	
7	~~CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.~~		25	~~INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS.~~	
8	INSPECT ~~CASES, MOUNTINGS, ANTENNAS, TOWERS, AND~~ EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE.		26	~~CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE.~~	
9	INSPECT ~~CORD,~~ CABLE, ~~WIRE, AND SHOCK MOUNTS~~ FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, ~~AND STRAIN.~~		27	~~INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS.~~	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		28	~~CHECK SETTINGS OF ADJUSTABLE RELAYS.~~	
11	~~INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.~~		29	~~LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.~~	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, ~~JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.~~		30	~~INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.~~	
13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~		31	~~CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS.~~	
14	~~CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.~~		32	~~INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE.~~	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES.		33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
16	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.~~		34	~~INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.~~	
17	~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~		35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
18	~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~		36	~~INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.~~	
			37	MOISTURE AND FUNGIPROOF.	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM320-17

Figure 11. DA Form 11-239.

25. General

The troubleshooting and repair work that can be performed at the organizational maintenance level is limited by the tools, test equipment, and replaceable parts issued.

26. Troubleshooting at Organizational Level

When the frequency-power meter fails to operate properly and the cause is not apparent, use the equipment performance checklist (par. 30) before starting a detailed examination. Obtain information from the operator of the equipment regarding the performance at the time trouble occurred. If the trouble is not located by simple observation, troubleshooting by a instrument repairman is necessary.

27. Tools and Test Equipment Required

a. The only tool supplied with the frequency-power meter is an Allen wrench which is located in the cable compartment in the cover. Additional tools that may be needed are found in Tool Equipment TE–113.

b. At organizational level the only item of test equipment required is Multimeter TS–352/U.

28. Visual Inspection

Failure of the frequency-power meter to operate properly usually will be caused by one or more of the following:

a. Deteriorated batteries.

b. Worn, broken, or disconnected cords or connectors.

c. Burned out thermistor.

d. Broken wires.

e. Inactive crystal.

29. Troubleshooting by Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 30) will help the repairman to locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures the repairman can take. *To use this list, follow the items in numerical sequence.*

b. Action or Condition. For some items, the information given in the action or condition column consists of various switch and control settings under which the item is to be checked. For other items it represents an action that must be taken to check the normal indication given in the normal indications column.

c. Normal Indications. The normal indications listed include the visible and audiblie signs that the repairman should see and hear when he checks the items. If the indications are not normal, the repairman should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those the repairman can make without turning in the equipment for repairs. A reference in the table to paragraph 39 indicates that the trouble cannot be corrected during operation and that trouble shooting by an instrument repairman is necessary.

30. Equipment Performance Checklist

		Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	ADJUST CURRENT COARSE and FINE controls.	Turn to extreme counterclockwise position.		
	2	TEST key	In BAL position.		
START	3	BAT switch	Throw to ON.	Meter needle will rise to midscale.	Check batteries.

		Item	Action or condition	Normal indications	Corrective measures
EQUIPMENT PERFORMANCE	4	COARSE and FINE controls.	Turn in clockwise direction.	Meter reading is balanced to zero.	See paragraph 39, symptom No. 5.
	5	GALV SENS button	Press. Repeat step No. 4.	A more accurate balance is obtained when the GALV SENS button is pressed.	See paragraph 39, symptom No. 4.
	6	TEST key	Place in the MEAS position.	The meter will indicate a reading which is recorded by operator as Reading No. 1.	See paragraph 39, symptom No. 2.
STOP	7	BAT switch	Throw to OFF.		
	8	COARSE and FINE controls.	Turn to extreme counterclockwise position.		

CHAPTER 4
THEORY

Section I. THEORY OF FREQUENCY AND POWER-MEASURING CIRCUITS

31. General

The power-measuring circuit of the frequency-power meter is a bridge circuit. One arm of the bridge is a radio-frequency chamber which contains a thermistor. The frequency-measuring circuit consists of a tunable coaxial cavity coupled by a loop across the transmission line (fig. 18).

32. Power-Measuring Circuit

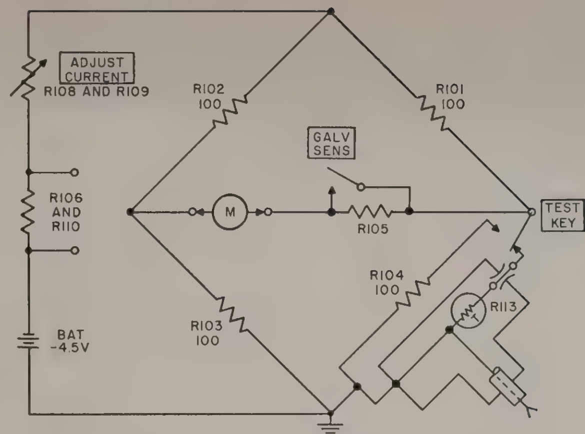
a. The dc path through the thermistor is one arm of the Wheatstone bridge circuit. The other three arms are resistances of 100 ohms each. The voltage impressed across the bridge by the battery supply is varied until the bridge is balanced. Bridge balance is indicated by a zero reading on the meter connected across the bridge. When a zero reading is obtained the thermistor is also 100 ohms (fig. 12).

b. The thermistor is a small semiconducting bead, the dc resistance of which will change as the power dissipated in it changes. To maintain a constant resistance for a given surrounding temperature, a constant power is required. This power may either be RF, dc, or a combination of the two. The method of determining the RF power consists of measuring the dc power required to obtain a thermistor resistance of 100 ohms when there is no RF input, and then measuring the dc power required to obtain a thermistor resistance of 100 ohms when both dc and RF power are applied to the thermistor. The RF power is the difference between the dc powers. Pulse signals from a radar transmitter may be measured in the same manner as cw power, but the duty cycle of the transimtter must be considered to obtain peak power. The power measurement made with the frequency-power meter is average power. The heating effect of pulse signals depends upon the duration of each pulse, the number of pulses per second, the peak power of each pulse, and the pulse shape.

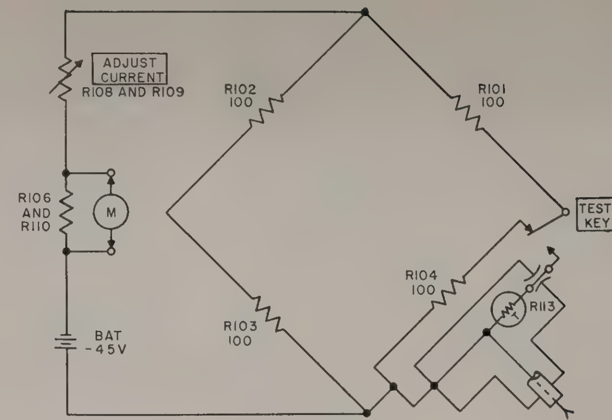
c. The fundamental circuits established in the course of making a power measurement are shown in figure 12, the complete schematic is found in figure 18. Referring to figure 12 diagram 1, the meter is connected across the bridge as a galvanometer and the ADJUST CURRENT resistances R108 and R109 are changed until the direct current through the thermistor causes its resistance to become 100 ohms; this balances the bridge. In diagram 2, the TEST key is shown in the MEAS position. A 100-ohm resistance is substituted for the thermistor. This substitution does not disturb the bridge balance. In this operation, the meter is bridged across a small resistance in the battery supply circuit. The value of this resistance is chosen so that the meter reads one-twentieth of the actual current flowing in the battery supply circuit. After the bridge is balanced, the current through the thermistor, or the 100-ohm resistance that is substituted for it, equals one-half of the battery supply current and, therefore, the meter reads one-tenth of the current through the thermistor or the 100-ohm resistance. The meter is calibrated in mw, corresponding to the dc power required by the thermistor for bridge balance. Each of the above operations is repeated in diagrams 3 and 4 with the RF input connected. A new bridge balance is established and a new value of direct current is read. Since the resistance of the thermistor is the same as before, the total power dissipated must be the same. The 100-ohm resistance is substituted for the thermistor when the bridge circuit is in the MEAS position, to provide circuit conditions that will allow the frequency-power meter to be used for adjusting the power output of a source, such as a signal generator, to a predetermined value.

d. The detailed calculation of power measured by the thermistor is as follows. Let the measured direct current with no RF input be I_1 and the dc power P_1

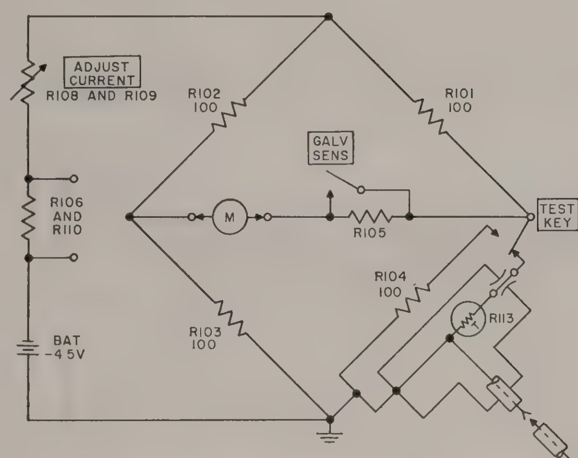
$$P_1 = I_1^2 \times 100$$



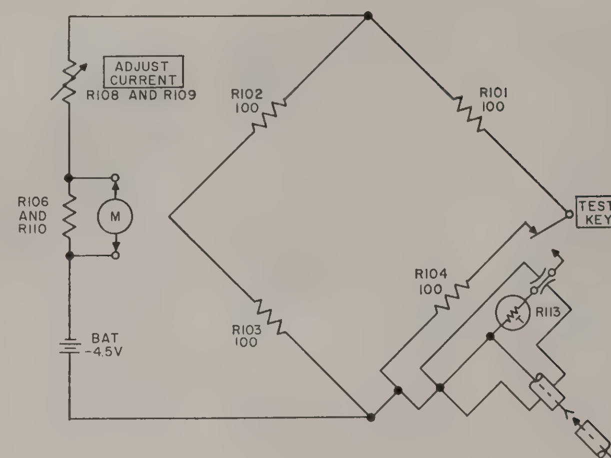
1. NO R.F. CONNECTED. "TEST" KEY ON "BAL" POSITION. BALANCE BRIDGE BY ADJUSTING R108 AND R109 UNTIL METER READS ZERO.



2. NO R.F. CONNECTED. "TEST" KEY ON "MEAS" POSITION.



3. R.F CONNECTED. "TEST" KEY ON "BAL" POSITION. BALANCE BRIDGE BY ADJUSTING R108 AND R109 UNTIL METER READS ZERO.



4. R.F. CONNECTED. "TEST" KEY ON "MEAS" POSITION.

TM320-11

Figure 12. Power measurements diagram.

With rf input, let $P_2 =$ the dc power in the thermistor, and $I_2 =$ dc current

$$P_2 = I_2^2 \times 100$$

With an RF input, the total power remains the same but is made up partly of RF and partly of dc.

Therefore,

$$P_1 = {}^{P} + {}^{2} \text{ (RF power)}$$

or

$$\text{(RF power)} = P_1 - P_2 = (I_1^2 \times 100) - (I_2^2 \times 100) = (I_1^2 - I_2^2)\ 100$$

To facilitate these computations, the meter scale is calibrated in mw equivalent to the power dissipated in a 100-ohm resistance. The reading on the mw scale is the dc power dissipated in the thermistor when its resistance is 100 ohms, and the difference between reading No. 1 and reading No. 2 is the RF power.

e. A slightly different procedure and computation are required when adjusting an RF power to a given value, such as adjusting the output of the signal generator to 6 mw. In this case, the RF power value is known before the measurement is started and need not be computed; P_1 is determined in the usual manner; and P_2 becomes the unknown. The unknown P_2 is readily determined by subtracting the desired RF power from P_1. If the thermistor were left in the circuit, a cut-and-try procedure would be required to obtain P_2 and the desired RF power to add up to P_1. To eliminate this cut-and-try procedure, a 100-ohm resistor is substituted for the thermistor when the TEST key is in the MEAS position. In the MEAS position, the controls can be adjusted to give the desired P_2 in the substituted 100 ohms. When the thermistor is restored, it is only necessary to adjust the RF power until the bridge is balanced. Under this condition, the thermistor is 100 ohms and the power dissipated in the thermistor is P_2 plus the desired RF power.

f. When balancing the bridge initially with dc only, the meter pointer first rises and then falls, because the resistance of the thermistor at first decreases more slowly than the current through the bridge increases. As the meter peak is reached, the resistance of the thermistor begins to decrease at a greater rate, and from this point the thermistor rapidly approaches 100 ohms, balancing the bridge and causing the meter reading to decrease to zero.

g. The thermistor is contained in a specially designed radio-frequency chamber (fig. 13). This assembly consists essentially of a coaxial line short-circuited to radio frequencies at each end, with the thermistor incorporated in the central conductor rod by split chuck arrangement which does not require soldering. The dimensions of this chamber and the location of the thermistor within it are chosen so that when the dc resistance of the thermistor is 100 ohms, the high-frequency impedance at the input MEAS PWR jack is approximately 50 ohms. At the round end of the chamber, the dc path is open, but an ac short-circuit path is produced by the small capacitors (polystyrene washers as dielectric). This prevents the dc present in the thermistor from being short-circuited by the RF chamber.

33. Frequency-Measuring Circuit

a. The frequency-measuring circuit is a tunable coaxial cavity (fig. 18). Coupling is made to the coaxial cavity by means of a loop bridged across the transmission line. The structure consists of a cylindrical chamber and a sliding central conductor the length of which projects into the chamber. The length of this conductor can be changed by operation of the MEAS FREQ knob. A counter dial indicates the relative length projecting into the chamber. In effect, this structure is a coaxial line of adjustable length. When adjusted to the applied frequency, the cavity produces a large reflection in the transmission line which results in the transmission of minimum power. The two ends of the transmission line terminate on the panel in the FREQ METER IN and OUT jacks. The frequency to be measured is connected to the input of this line and the thermistor circuit is connected at the output end. With the frequency-power meter detuned, there is a given power input to the thermistor circuit. Under this condition, the bridge is adjusted for balance, a zero reading on the meter. The frequency-power meter is then adjusted by means of the MEAS FREQ knob until the cavity is tuned to reasonance with the input frequency. When the cavity is tuned, the power delivered to the thermistor is decreased. Decreasing the power causes the bridge circuit to become unbalanced, because of the change in thermistor resistance, and the meter will deflect upward. From the setting of the MEAS FREQ indicator, the applied frequency can be deter-

mined from the calibration chart as described in paragraph 16*i*.

b. Frequency measurements can also be made by using the crystal. The output of the crystal detector circuit will vary directly with the power. When making frequency measurements, a minimum indication is obtained at resonance as compared with maximum indication when using the thermistor circuit. When making frequency measurements of pulsed signals, the frequency-power meter is tuned for minimum amplitude at the center of the pulse image viewed on an oscilloscope connected to the CRYSTAL VIDEO jack.

Section II. THEORY OF CRYSTAL DETECTOR AND CONNECTING CABLES

34. Crystal

The crystal serves as a rectifier of pulsed power, providing a video output for use with an oscilloscope to view the pulses. An oscilloscope, either self-triggering or synchronized with the transmitter sending out the pulsed power is required to view pulses. The peak power impressed upon the crystal should not exceed 1 watt (+30 dbm). For this reason, always connect the 10-db cable to the reflected power output jack of a directional coupler when using the crystal. No output control is provided; it is assumed that such a control is included in the oscilloscope itself. For use on radar systems having a unidirectional coupler, that is, a coupler having only one output jack, connection may be made by inserting an additional 20- to 30-db loss cable between the frequency-power meter crystal detector and the coupler.

35. Connecting Cables

a. The 10-db cable is made up of 11 feet of 50-ohm coaxial cable the length of which has been adjusted to 10 ±.5 db at 3,500 megacycles. The cable consists of a central conductor of high-resistance wire surrounded by a low-loss dielectric material. The result is a cable the temperature coefficient of which is low, and therefore, temperature changes may be disregarded. The frequency characteristic of the cable is shown in figure 6.

b. The loss of the 5-foot low-loss cable is 1 db. It is used when the power is too low to measure accurately with the 10-db cable in the circuit, as when the radar is in trouble or when measuring very low values of reflected power.

c. The 6-inch patch cable is used for connecting between FREQ METER and MEAS PWR jacks on the frequency-power meter.

d. All the above cables have plug connections. In addition, a 3-db connecting cable with a plug on one end and a jack on the other end is provided to extend the range of the 10-db cable when measuring high powers.

CHAPTER 5
FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by tools and test equipment available and by the skill of the repairman.

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

Caution: Do not attempt to repair the frequency meter (cavity). Do not attempt to remove or unscrew the smaller of the two milled knobs on the crystal block. This is a quarter wavelength stub the center conductor of which is soldered in place (fig. 15). Observe the cautions given in paragraph 43 for handling crystals.

36. Troubleshooting Procedures

The first step in servicing a defective test set is to sectionalize the fault. Sectionalization means tracking the fault to the major circuit responsible for the abnormal operation of the set. The second step is to localize the fault. Localization means tracking the fault to the defective part responsible for the abnormal condition.

37. Troubleshooting Data

Compare the schematic diagram in the manual with the circuit label if one is included with the equipment. The use of the material supplied in the manual will help in the rapid location of faults. The following illustrations will help when troubleshooting the frequency-power meter.

Fig No.	Title
4	Front panel view.
13	Thermistor housing.
14	Removing crystal.
15	Left rear view of panel.
16	Right rear view of panel.

38. Test Equipment Required for Troubleshooting

The only tests that can be made when troubleshooting a defective frequency-power meter are continuity, resistance, and voltage checks. Use Multimeter TS–352/U (TM 11–5527).

39. Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the test set. This chart lists the symptoms which the repairman observes while making a few simple tests.

Symptom	Probable trouble	Correction
1. In attempting to balance bridge, no reading is obtained on meter for any position of COARSE control.	BAT switch at OFF.	Set BAT switch to ON.
	Battery voltage zero or very low.	Replace batteries.
	Open in circuit through battery, R108, R109, and BAT switch.	Check with an ohmmeter and replace defective component or repair open wiring or switch contact.
	Shunt R110 or R106 defective or meter M101 defective.	Connect an external calibrated milliammeter (0 to 50 ma) of .5 per cent accuracy in series with the internal battery. Place the TEST key to the MEAS position and the BAT switch to ON. Adjust the COARSE and FINE knobs to give a full-scale reading of 22.5 mw on the meter (M101) in the set. If this reading is not obtainable, adjust the COARSE and FINE knobs until the external meter reads 30 ma. Adjust R110 (fig. 16) inside the

Symptom	Probable trouble	Correction
		set until M101 reads full scale (22.5 mw). If this results in a position of R110 close to its minimum and the adjustment is very critical, it is an indication that fixed shunt R106 is open or is greatly in excess of 4.4 ohms. Check this as follows: (1) disconnect the leads from the meter in the set; (2) throw the BAT switch to ON; (3) disconnect the lead to the negative side of the battery; (4) measure with a Wheatstone bridge across the leads which normally connect to the meter. The reading should be 3.90 ohms ±1% with R110 more than one-fourth of the way from its minimum position. If this value is not obtained, replace shunt R106. If the shunts are satisfactory, replace meter M101.
2. No meter reading with TEST key at MEAS although there is a reading with TEST key in BAL position.	R106 is shorted or there is a short in the key contacts.	Use ohmmeter to check key contacts and wires. Replace defective part or repair short in wiring or key contact.
3. In attempting to balance bridge, there is an irregular motion of needle.	Poor contact in the COARSE or FINE potentiometer or in TEST key contacts.	With BAT switch OFF, check with ohmmeter and replace defective part or establish good circuit in key or wiring.
4. In attempting to balance bridge, operating GALV SENS button key has no effect.	GALV SENS button contacts are dirty, or GALV SENS button or R105 is shorted.	Clean contacts of GALV SENS button. Check GALV SENS button and R105 with ohmmeter: TEST key on MEAS and BAT switch OFF. Replace defective component.
5. The bridge cannot be balanced to zero by any setting of the COARSE and FINE potentiometers.	A bridge element is defective.	Set BAT switch to ON. Set TEST key to MEAS. Turn COARSE and FINE knobs to extreme clockwise position. If meter reads lower than 20 mw with no rf connected, replace batteries. Throw BAT switch to OFF. Remove thermistor. Check resistance from insulated terminal at round end of rf chamber to its framework. Resistance should be approximately 300 ohms. Zero reading indicates a short around the thermistor. Remove shorting particles or replace RF chamber. Examine space around rod at end of RF chamber for metallic particles. If necessary, unscrew plug assembly at end of RF chamber and examine dielectric washers. Make certain that each end of thermistor rod is inserted in the chuck end of the center conductor. Replace the thermistor. Throw BAT switch to OFF and TEST key to MEAS. Measure across each resistor. Each resistor will indicate 75 ohms ±.8 ohms if others are good. If 100 ohms is measured, the resistor is good and one of the others is open. Replace defective resistor.

Section II. REPLACEMENT OF PARTS

40. Removal of Set from Box

The chassis is fastened to the box by four screws at the corners of the panel (fig. 4). Remove chassis by loosening these screws.

41. Replacing Batteries

Replace batteries as described in paragraph 12.

42. Removal and Replacement of Thermistor

A spare thermistor is carried in a container under the knurled cap designated SPARE THERM. When removing the spare thermistor, leave the small piece of felt surrounding the thermistor in the container. To remove the old

thermistor from the RF chamber and insert a new one, proceed as follows:

a. Remove the four small machine screws near the center of the RF chamber where the square and round portions meet (fig. 13).

b. Separate the two parts of the assembly and remove the thermistor from the split chuck ends of the central conductor.

c. Insert the leads of the new thermistor into the ends of the central conductor, with the metal collar end of the thermistor toward the parts of the chamber assembly; be sure to maintain approximate alignment so that the split chucks will not be sprung.

d. Replace the four screws in the RF chamber assembly.

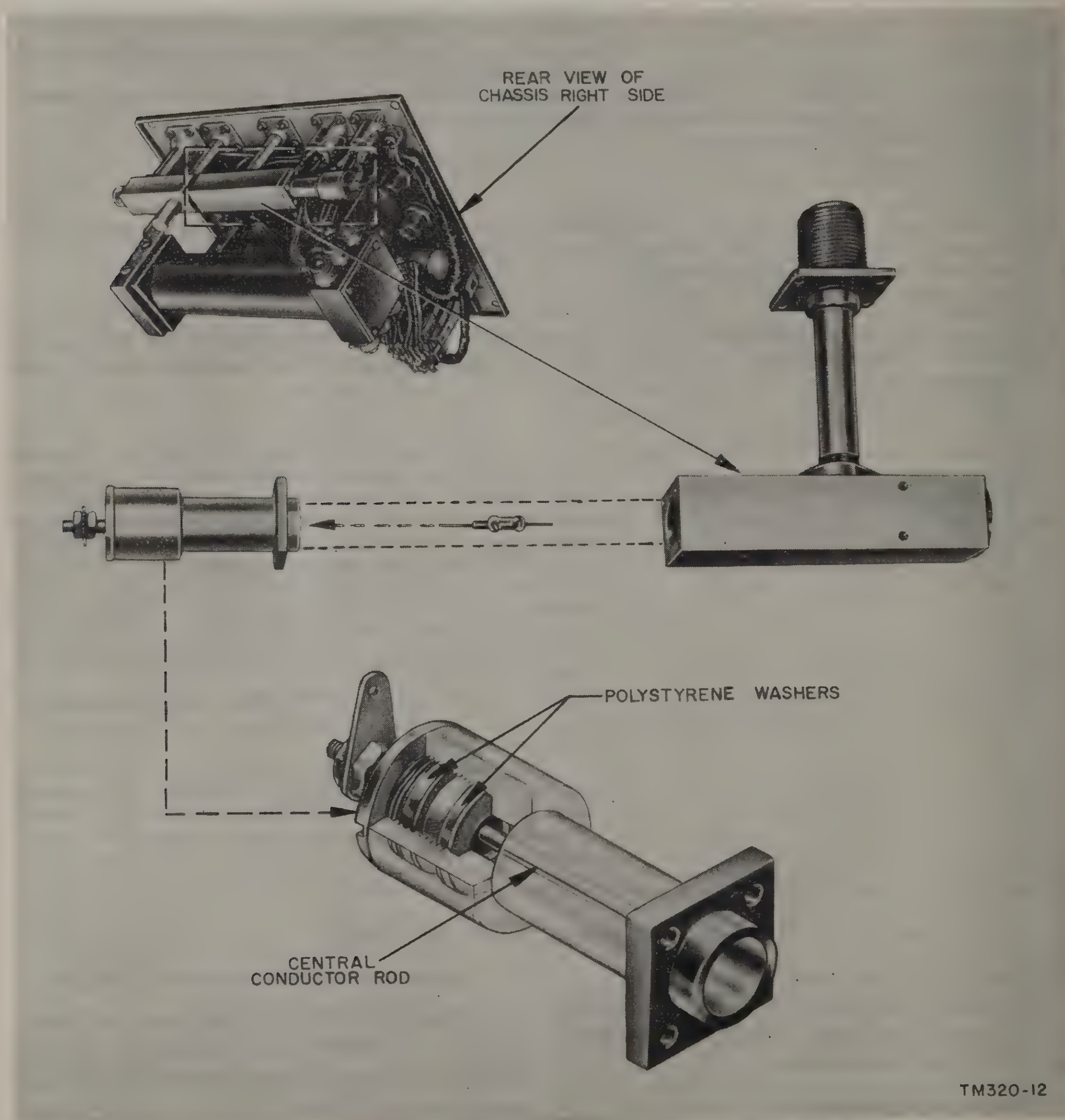


Figure 13. Thermistor housing.

43. Replacing Crystal

a. The crystal block is mounted with the CRYSTAL IN and VIDEO jacks on the back of the panel (fig. 15). The block is supported by the jacks and by an attachment to the RF chamber. A spare crystal is carried in the container under the knurled cap designated SPARE CRYSTAL.

Caution: The electrical characteristics of the crystal will be impaired if excessive electrical currents pass through the unit. Minute static charges not readily detectable are enough to cause damage. Do not expose the crystal to static discharge shocks. A static charge may be accumulated, particularly in dry weather, by the motion of the operator's feet across an insulated floor. If the apparatus into which the crystal is to be inserted is not grounded, the apparatus may have accumulated a static charge. In either case, there is a possibility of damage to the crystal due to the passage of electrical discharge currents through it. This may be avoided by touching the hand that holds the new crystal to the crystal block before and while inserting the new crystal in the block. Similarly the knurled cap should be touched to the crystal block before attaching the cap to the crystal. The crystal may also be damaged by power absorbed from intense fields set up by a near-by operating radar transmitter. The hazard is greatly reduced by retaining the metal foil wrapping around the crystal until it is to be placed in the crystal block, and by shutting down the radar transmitter before removing the metal foil wrapping and while inserting the crystal in the block.

b. To replace the crystal, proceed as follows:

(1) Unscrew the large knurled cap at the end of the crystal block (fig. 14). Pull it out. The crystal (mounted on it) will come with it.

(2) The method of removing the crystal is shown in figure 15. Grip the left end of the cap assembly. Unscrew the cap ½ turn to release the cartridge.

(3) Remove the metal foil from the new crystal after making sure that no radar transmitter is operating near by.

(4) Place the new crystal in the holder and fasten it by turning the knurled cap.

(5) Insert the crystal, mounted on the knurled cap, in the crystal block; be sure the top of the crystal is properly seated in the chuck.

44. Ten-db and 3-db Cables

Never attempt to repair the 10-db and 3-db cables. If either is damaged, replace it.

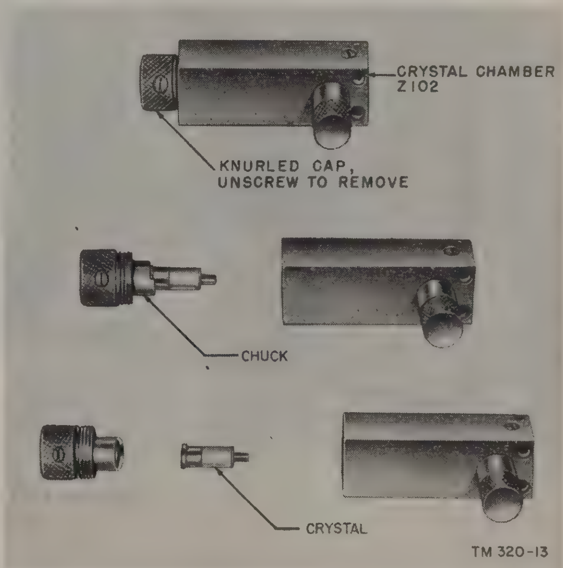


Figure 14. Removing crystal.

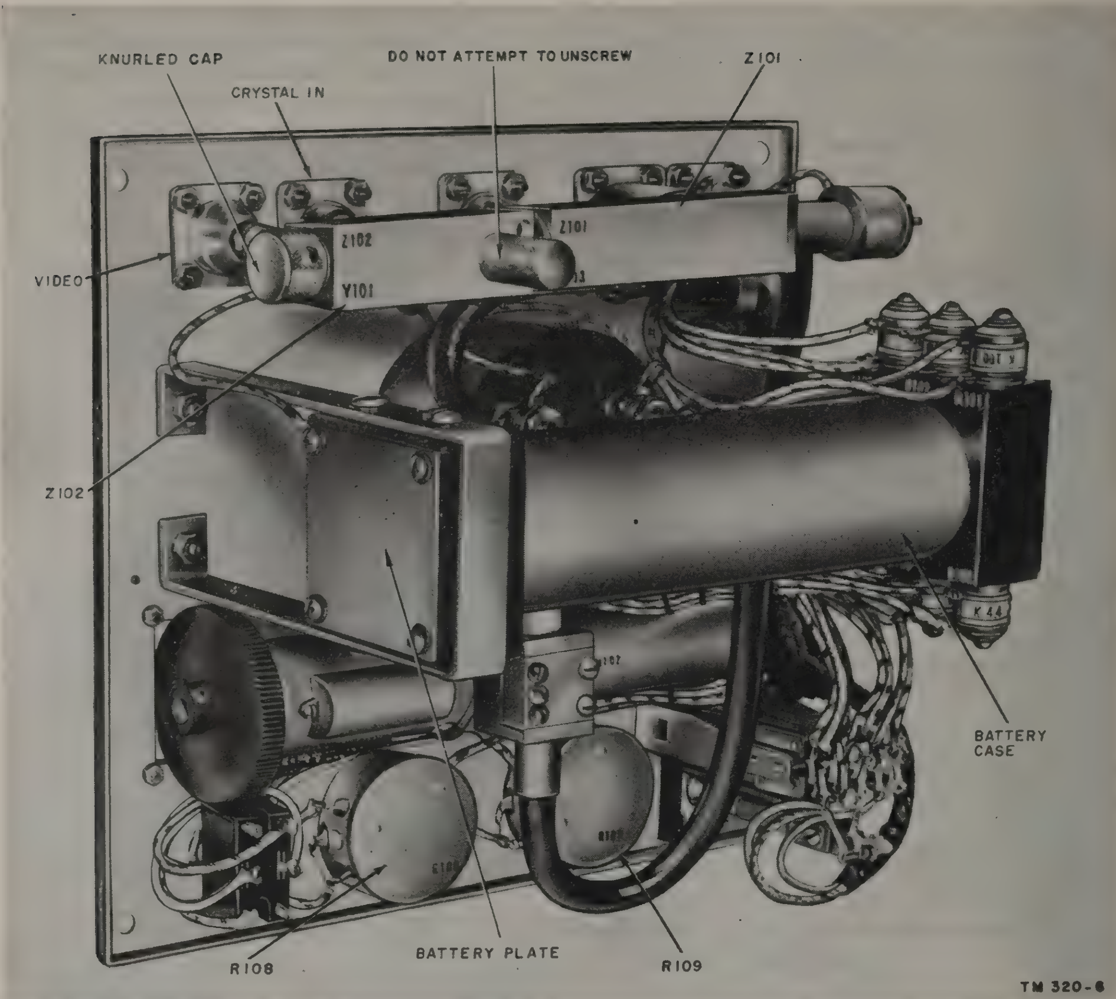


Figure 15. Left rear view of panel.

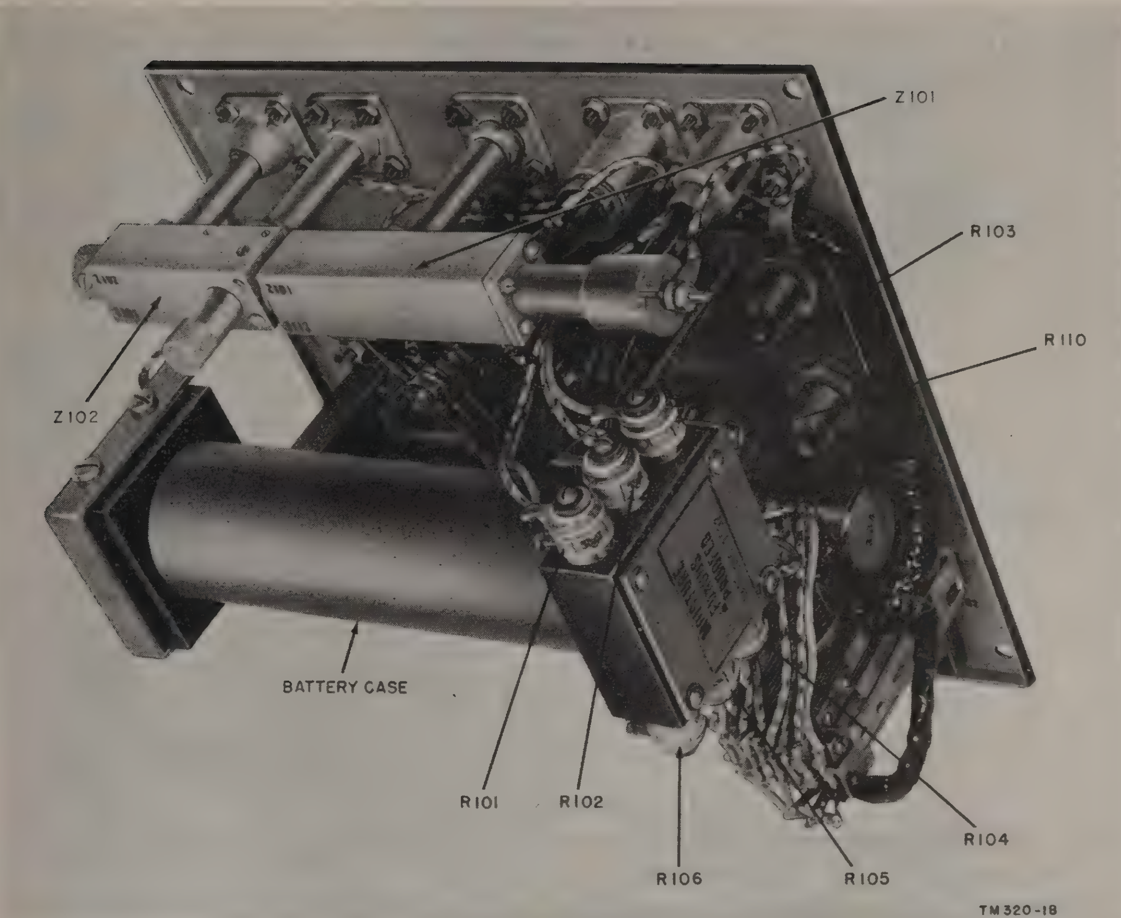
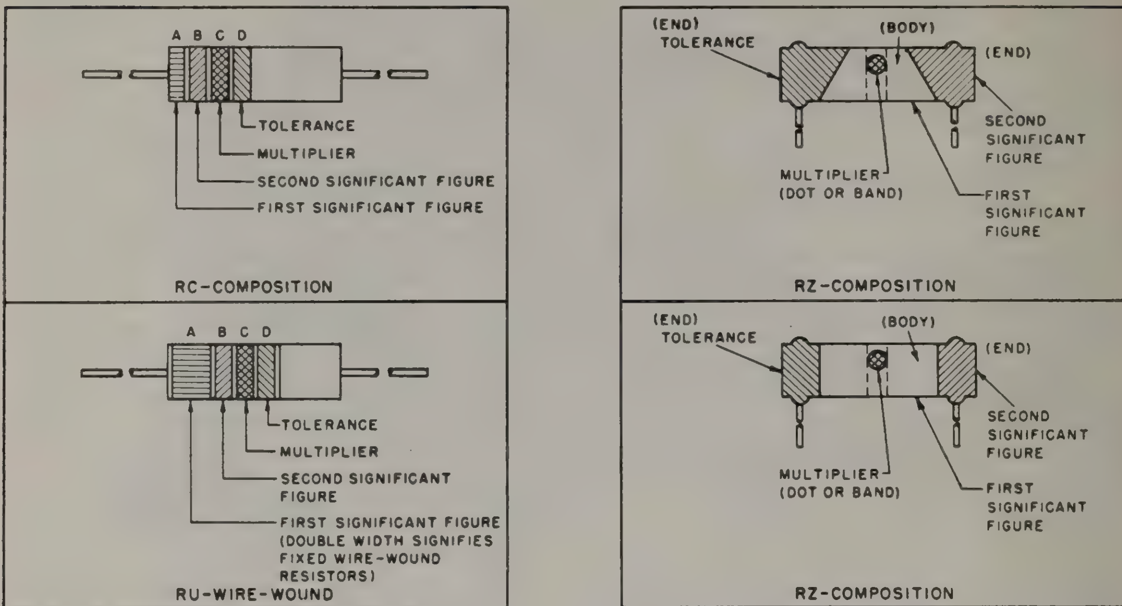


Figure 16. Right rear view of panel.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED) | RADIAL-LEAD RESISTORS (UNINSULATED)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

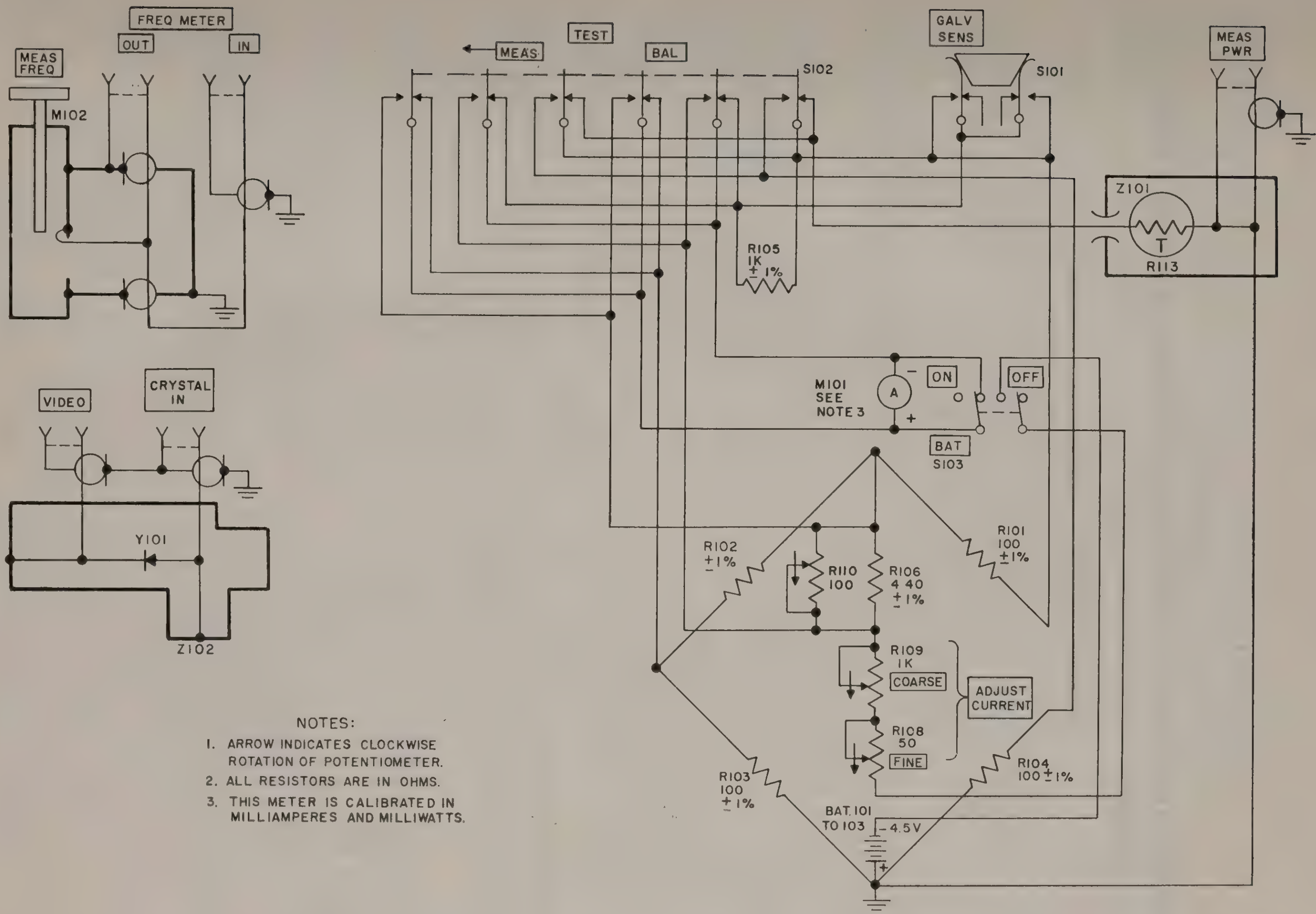
*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B, BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY, BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY, BLACK END, RED DOT OR BAND; SILVER END.

STD-R1

Figure 17. Resistor color code.



NOTES:

1. ARROW INDICATES CLOCKWISE ROTATION OF POTENTIOMETER.
2. ALL RESISTORS ARE IN OHMS.
3. THIS METER IS CALIBRATED IN MILLIAMPERES AND MILLIWATTS.

Figure 18. Frequency-Power Meter ME–51/UP, schematic diagram.

CHAPTER 6
SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

45. Disassembly of Equipment

Use the following procedure to prepare Frequency-Power Meter ME–51/UP for shipment and storage.

a. Remove the three Batteries BA–30 from the battery case as follows:

(1) Remove the unit from its case by unscrewing a screw from each corner of the front panel (fig. 4).

(2) Remove the battery case cover.

(3) Remove the batteries from the case (fig. 13).

(4) Replace the battery case cover.

(5) Replace the unit in its case.

b. Place the four cables in the case cover as shown in figure 2. Place the cover on the equipment and fasten it.

46. Materials Required

a. The following materials are required for packaging Frequency-Power Meter ME–51/UP:

Material	Quantity
Flexible corrugated paper	4 square feet
Barrier material, waterproof	4 square feet
Gummed paper tape	2 feet
Pressure-sensitive tape	2 feet
Flat steel strapping	5 feet
Wooden shipping boxes required	1 each

b. The wooden box is 12 inches long by 12 inches wide by 14 inches deep and has a volume of 1.1 cubic feet. Nine board feet of lumber are required. The packaged weight is 16 pounds.

47. Field Repackaging

Package each Frequency-Power Meter ME–51/UP in accordance with the following procedure:

a. Place each manual within a close-fitting bag of waterproof barrier material. Seal the seams of the bag with water-resistant, pressure-sensitive tape.

b. Cushion each meter on all surfaces with pads made of the flexible single-faced corrugated paper. These pads are designed to absorb the shock of impact normally encountered in handling and transit. Fasten these pads with gummed paper tape.

48. Field Packing and Marking

Pack each Frequency-Power Meter ME–51/UP as follows:

a. Build a wooden box to the dimensions given in paragraph 43*b*. Make a waterproof liner for the box by using barrier material and pressure-sensitive tape. Place the packaged frequency-power meter within the box. Be sure it fits snugly so that it cannot move around and be damaged in transit.

b. Place the cover on the box and nail it in place. Strap the shipping container for intertheater shipment only.

c. Mark the shipping container in accordance with the requirements of section II, SR 55–720–1, Transportation and Travel, Preparation for Oversea Movement of Units (POM).

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

49. General

The demolition procedures outlined in paragraph 50 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

50. Methods of Destruction

a. Smash. Smash the crystals, thermistors, controls, meter, switches, connectors, and resistors; use a sledge, axe, handaxe, pickaxe, hammer, crowbar, or other heavy tool.

b. Cut. Cut cables and wiring; use an axe, handaxe, or machete.

c. Burn. Burn cables, resistors, wiring and manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend the case and panel.

e. Explode. If explosives are necessary, use grenades, or TNT.

f. Dispose. Bury or scatter the destroyed parts in a slit trench, fox hole, or other hole, or throw them into a stream.

[AG 431.44 (29 Oct 56)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:
JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Army:

- CNGB (1)
- ASA (3)
- Tec Svc, DA (1) except CSIGO (30)
- Tec Svc Bd (1)
- Hq CONARC (5)
- CONARC Bd (Incl ea Test Sec) (1)
- Army AA Comd (2)
- OS Maj Comd (5)
- OS Base Comd (5)
- Log Comd (5)
- MDW (1)
- Armies (5)
- Corps (2)
- Ft & Cp (2)
- Sp Wpn Comd (2)
- Army Cml Cen (4)
- Gen & Br Svc Sch (5) except Sig Sch (25)
- Gen Depots (2) except Atlanta Gen Depot (None)
- Sig Sec, Gen Depots (10)
- Sig Depots (17)
- US Army Tng Cen (2)
- POE (OS) (2)
- Trans Terminal Comd (2)
- Army Terminals (2)
- OS Sup Agencies (2)
- Army Elct PG (1)
- Sig Fld Maint Shops (3)
- Sig Lab (5)
- ACS (3)
- Mil Dist (1)
- Units org under fol TOE:
  - 11–7C, Sig Co, Inf Div (2)
  - 11–16C, Hq&HqCo, Sig Bn, Corps or Abn Corps (2)
  - 11–57C, Armd Sig Co (2)
  - 11–127R, Sig Rep Co (2)
  - 11–128C, Sig Depot Co (2)
  - 11–500R, Sig Svc Org (2)
  - 11–557C, Abn Sig Co (2)
  - 11–587R, Sig Base Maint Co (2)
  - 11–592R, Hq&Hq Co, Sig Base Depot (2)
  - 11–597R, Sig Base Depot Co (2)

NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.

USAR: None.

For explanation of abbreviations used, see SR 320–50–1.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1956—400505

TECHNICAL MANUAL

FREQUENCY-POWER METER 51/UP

TM 11-320
CHANGES No. 1

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *4 September 1959*

TM 11-320, 14 November 1956, is changed as follows:
Page 29.

Section III. CALIBRATION

44.1. Test Equipment Required for Calibration

The following chart lists the test equipment required for calibrating Frequency-Power Meter 51/UP, the associated technical manuals, and the assigned common names.

Test equipment	Technical manual	Common name
Frequency Meter TS-186/UP	TM 11-2691-15	Frequency meter
Multimeter TS-352/U	TM 11-5527	Multimeter
Signal Generators TS-403/U	TM 11-5091	Signal generator
Meter Test Set TS-682/GSM-1	TM 11-2535B	Test set

44.2. Procedure for Calibrating Meter M101

Before attempting to calibrate meter M101, first set the meter test set for an output of 30 ma. With the multimeter connected (50 ma range), note the multimeter reading and use this as the 30 ma reference. After this has been accomplished, proceed as follows:

a. Remove the frequency-power meter panel-chassis assembly from its case.

b. Adjust meter M101 for zero position (par. 14).

c. Observing polarity, connect the multimeter in series with the frequency-power meter internal battery. Be sure the multimeter is set to the same range for which it was calibrated.

d. Place the TEST key on the frequency-power meter to MEAS position and the BAT switch to ON.

e. Adjust the COURSE and FINE controls on the frequency-power meter until the multimeter reads 30 ma.

f. Adjust R110 (fig. 16) until meter M101 reads full scale (22.5 mw).

Note. If this adjustment results in a position of R110 close to its minimum limit and the adjustment is critical, refer to the correction column of paragraph 39, symptom 1.

44.3. Bridge Balance

a. Adjust the COURSE and FINE controls on the frequency-power meter to their extreme counterclockwise position.

b. Place the TEST key to the BAL position.

c. Place the BAT switch to ON.

d. Adjust the COURSE and FINE controls for a zero reading on meter M101. Zero indicates bridge balance.

e. Depress the GALV SENS button and adjust the FINE control for exact balance condition.

f. If the bridge cannot be balanced or acts erratically, refer to paragraph 39.

44.4. Frequency Calibration

a. General. When a final test (par. 44.10) indicates that the cavity is within 2 mc of the standard test frequency (when compared to the original calibration chart) but does not coincide with the latest frequency calibration card, a new calibration card must be prepared.

b. Procedure.

(1) Connect the RF OUTPUT jack of the signal generator to J104 of the frequency meter (TS–186/UP).

(2) Adjust the signal generator for maximum output as 3,100 mc as indicated on the frequency meter.

(3) Disconnect the signal generator from the frequency meter.

(4) Connect the RF OUTPUT jack of the signal generator to the FREQ METER IN jack of the frequency-power meter.

(5) On the frequency-power meter, connect the FREQ METER OUT jack to the MEAS PWR jack.

(6) Adjust the frequency-power meter to measure the frequency of the signal generator (par. 16). Note the MEAS FREQ dial counter to four places.

(7) Repeat the procedures given in (1) through (6) above at every 20-mc interval to 3,500 mc.

(8) Plot the calibration curve and attach it to the frequency-power meter. Label the card to indicate that it is the new calibration card to be used for frequency measurements.

Note. Do not discard the original card because it will be required for frequency accuracy tests.

CHAPTER 5.1
FINAL TESTING
(Added)

44.5. General

The testing procedures in this chapter are used to determine the quality of a repaired frequency-power meter. The test requirements outlined in paragraph 44.8 through 44.10 will be performed only by personnel with adequate tools and test equipment, and with the required training and skills.

44.6. Tools and Test Equipment Required

The following tools and test equipment are required for final testing:

Tools and test equipment	Technical manual	Common name
Wattmeter AN/URM–98	TM 11–5124	Wattmeter
Multimeter TS–352/U	TM 11–5527	Multimeter
Variable Attenuator CN–220/U		Attenuator
Klystron, 2K41 (tuned to 3,300 mc)		Klystron
Klystron Power Supply PP–962/U or equivalent		Power supply
Connector Adapter UG–400/U (2 each)		Adapter
Resistor, variable, 5,000-hm		Resistor

44.7. Test Setup

To perform the final tests on the frequency-power meter, first connect the equipment as shown in figure 14.1. Modifications to this setup will be made as required for the individual tests.

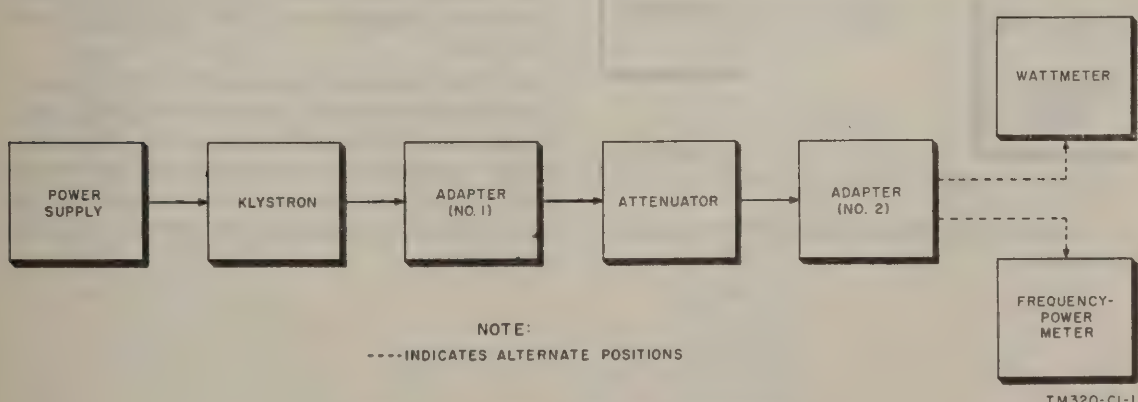


Figure 14.1. (Added) *Test setup, final testing.*

44.8. Power Accuracy Test

a. With the test equipment setup as shown in figure 14.1, connect the wattmeter to adapter No. 2.

b. Adjust the attenuator for .5 mw on the wattmeter.

c. Disconnect the wattmeter from the adapter and connect the frequency-power meter to the adapter.

d. Adjust the frequency-power meter to measure power. The reading should be from .397 to .63 mw.

e. Repeat the procedures given in *a* through *d* above at a power level of 5 mw. When measuring the 5-mw level, the reading on the frequency-power meter should be from 3.97 to 6.3 mw.

f. Repeat the procedures given in *a* through *d* above at a power level of 12.5 mw. Since the maximum power than can be measured with the wattmeter is 10 mw, first adjust the attenuator for 10 mw, then disconnect the wattmeter and decrease the attenuator .96 db. The output from the equipment will then be 12.5 mw. The reading on the frequency-power meter should be from 9.9 to 15.75 mw.

44.9. Crystal Output Test

a. Connect the test equipment as shown in figure 14.1.

b. Adjust the frequency-power meter to measure power and connect it to adapter No. 2.

c. Adjust the attenuator for a reading of 6 mw on the frequency-power meter.

d. Turn off the power supply.

e. With the multimeter connected to measure current on its 10 ma range, disconnect the frequency-power meter cables and connect the output of adapter No. 2 as shown in figure 14.2.

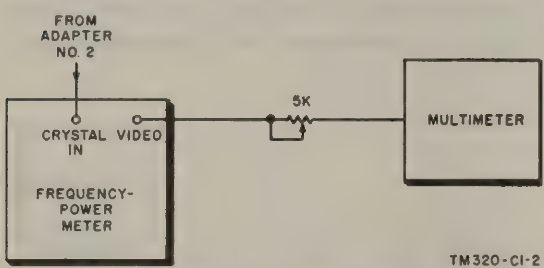


Figure 14.2. (Added) Test setup, crystal output test.

f. Adjust the 5,000-ohm resistor for maximum resistance.

g. Turn on the power supply.

h. The multimeter should read at least 1.5 ma when the 5,000-ohm resistor is adjusted for minimum resistance.

44.10. Frequency Accuracy Test

a. Connect the signal generator RF output jack to J–104 of the frequency meter (TS–186/UP).

b. Adjust the signal generator to maximum output at 3,100 mc as indicated on the frequency meter.

c. Disconnect the signal generator.

d. Connect the signal generator output to the FREQ METER IN jack of the frequency-power meter.

e. On the frequency-power meter, connect the FREQ METER OUT jack to the MEAS PWR jack.

f. Adjust the frequency-power meter to measure the signal generator frequency. Note the MEAS FREQ dial connter reading. Locate this reading on the original calibration card furnished with the frequency-power meter and determine the indicated frequency. The frequency should be 3,100 mc ±2 mc in comparison. Note the reading. If the reading is off more than 2 mc, the coaxial cavity must be replaced.

g. Repeat the procedures given in *b* through *f* above at frequencies of 3,200, 3,300, 3,400 and 3,500 mc.

h. If the indicated frequency of the frequency-power meter is within 2 mc of the original calibration chart, the unit is acceptable. However, if the indicated frequency and the frequency determined from the latest calibration card are not identical, prepare a new calibration card (par. 44.4).

[AG 413.44 (19 Aug 59)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

L. L. LEMNITZER,
General, United States Army,
Chief of Staff.

Official:

R. V. LEE,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Army:

ASA (2)
CNGB (1)
Def Atomic Spt Agcy (5)
Tech Stf, DA (1) except
CSigO (18)
Tech Stf Bd (1)
USCONARC (5)
USA Arty Bd (1)
USA Armor Bd (1)
USA Armor Bd Test Sec (1)
USA Inf Bd (1)
USA Air Def Bd (1)
USA Air Def Bd Test Sec (1)
USA Abn & Elct Bd (1)
USA Avn Bd (1)
USA Arctic Test Bd (1)
US ARADCOM (2)
US ARADCOM Rgn (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
USA Ord Msl Comd (3)
MDW (1)
Armies (5) except
First US Army (7)
Corps (2)
Div (2)
USATC (2)
Yuma Test Sta (2)
USA Elct Pg (1)
Svc Colleges (5)
Br Svc Sch (5) except
USASCS (25)
Gen Depots (2) except
Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (17)
Port Clinton Ord Depot (5)
AFIP (1)
WRAMC (1)
AMS (1)
Engr Maint Cen (1)
USA Comm Agcy (2)
USA Sig Engr Agcy (1)
USA Sig Pub Agcy (8)
USA Sig Eqp Spt Agcy (2)
USA Sig Msl Spt Agcy (13)
Ports of Emb (OS) (2)
Trans Terminal Comd (1)
Army Terminals (1)
OS Sup Agcy (1)
Sig Fld Maint Shops (3)
Sig Lab (5)
USA Pictorial Cen (2)
USASSA (15)
Mid Western Rgn Ofc (USASSA) (1)
Mil Dist (1)
Sectors, US Corps (Res) (1)
USA Corps (Res) (1)
JBUSMC (2)

Units org under fol TOE:
11–7 (2)
11–16 (2)
11–57 (2)
11–98 (2)
11–117 (2)
11–155 (2)
11–500 (AA–EE) (2)
11–557 (2)
11–587 (2)
11–592 (2)
11–597 (2)
44–145 (2)
44–147 (2)
44–445 (2)
44–447 (2)
44–448 (2)
44–535 (2)
44–537 (2)
44–545 (2)
44–547 (2)
44–549 (2)

NG: State AG (3); units—same as Active Army except allowance is one copy to each unit.

USAR: None.

For explanation of abbreviations used see AR 320–50.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1959—520503

TM 11-320 — FREQUENCY-POWER METER ME-51/UP — 1956